THE MANUFACTURE AND TRANSPORTATION OF GUNPOWDER IN THE OTTOMAN EMPIRE: 1400-1800

by

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ABSTRACT

This thesis attempts to analyze the reasons for the Ottoman Empire's successful expansion in the 1400s-1800s and its ultimate decline in the 1800s-1900s through the perspective of its national gunpowder factories and gunpowder transportation capabilities. Ultimately, all premodern firearms were only as powerful as the gunpowder they used, and a recurrent problem for all gunpowder armies was the unreliability of their powder. Such unreliability became the primary cause for the loss of a battle or an entire campaign.

In comparison with their rivals to the west and to the east, the Ottomans displayed an unparalleled aptitude for the manufacture and transport of gunpowder. The abundance of natural resources, such as high quality saltpeter, sulfur, and the right kind of trees for producing charcoal, when combined with the Ottomans' highly sophisticated state-run gunpowder works and excellent transportation network, was a major factor in their stunning successes between the 1450s and 1700s. By looking at several prime examples of the Ottoman manufacturing and transportation systems in action, we can see how a highly developed state-organized machine triumphed again and again against rivals who came to the battlefield with inferior gunpowder in some of the period's most decisive battles. Between 1800 and 1900, however, state control over these vital wartime industries experienced a decline coinciding with the Empire's inability to produce sufficient gunpowder and the financial burden which resulted from having to import it.

For Meredith,

Pradun.

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CHAPTER 1

INTRODUCTION TO THE OTTOMAN EMPIRE

In the mid 15th century the Islamic world had just come through a period almost as trying as its expansion from the Arabian Peninsula in the 7th century. A series of destabilizing events had put the fledgling Islamic nation in a precarious position. The first was the aggression of the Christian West which included the invasion of the Crusaders from Western Europe in the 12th and 13th centuries: the *reconquista* of Muslim Iberia, with the assistance of the Genoese and Portuguese, opened the Straits of Gibraltar to European shipping, and eventually to European domination of the shipping lanes in the entire Mediterranean Sea and its islands. Although the Crusaders lost their conquests in Palestine and Syria to the Mamluks, Western Europeans began bypassing the Islamic world by opening up the sea route around the Cape of Good Hope through which they could directly tap into the rich trade opportunities in India, Indonesia, and China, and thereby break the monopoly that Islam had on trade with the East.

The second major event was the coming of the Mongols, which represented a threat to Islam much more potent than the Crusaders ever presented. In the middle of the thirteenth century Mongol armies had conquered Seljuk Asia Minor, overrun Khorasan, Persia, and Iraq, and launched continual attacks against Muslim held Syria. The Mongol destruction of Baghdad in 1258 terminated the Abbasid caliphate in Baghdad, and it was

not until an Abbasid turned up in Cairo and was installed as caliph by the Mamluks that the Islamic world regained its traditional form of religious leadership.

In Syria and Palestine too, Muslim authorities were so fearful of another crusader attack that they tore down all seaport fortifications except at Beirut and Alexandria and withdrew into the interior cities such as Aleppo, Cairo, Ramla and Damascus, where they could feel secure. Thus, by the 1350s, the Islamic world had withdrawn into a defensive position, facing an uncertain future with caution.

By the following century, Mamluk Egypt, under the strong leadership of Baybars, had created armies of elite cavalry regiments capable of defeating the Mongols in battle. At much the same time, in the early 14th century, the Turkish tribal chieftain ‘Uthman (1258-1326) founded a principality that eventually grew into an empire in western Anatolia that was to expand and endure for almost six centuries. This empire grew first by conquering the Balkan territories of the Byzantine Empire and at the height of its power extended to all of Asia Minor, the Kingdoms of the Balkan Peninsula, the islands of the eastern Mediterranean, parts of Hungary, the Russian steppes, Iraq, Syria, the Caucasus, Palestine, Egypt, parts of Arabia, and all of North Africa through Algeria. After the defeat of the Seljuks by the Mongols at Kösedağ in 1243, ‘Uthman emerged as the leader of the local Turks in the fight against the weakening Byzantine Empire. He started a dynasty that would emerge from this turmoil as one of the foremost powers in the world. Although the Ottoman Empire controlled much of the old Middle Eastern heartland of Islam during its existence, and ruled almost all the Arabic-speaking world at its height, it was something new. The power of the Ottomans was not based on the old

countries of Syria, Egypt, and Iraq. The importance of these countries was declining as the balance of trade moved further west.

Early Ottoman sultans such as Murat I (1362 – 1389) and his successors were quick to grasp the significance of gunpowder, perhaps because they already excelled in the use of ranged weapons, such as the composite bow, and it was a natural step to embrace gunpowder as an upgrade to their current ranged weapon technology. In the late 14th century, sultan Murat I created the janissaries corps: a standing, mostly infantry army, nicely suited for equipment with firearms. The real question is not who first used firearms, but who used them first effectively enough to have significant impact on the outcome of battles and sieges. Most of the earliest dates with regard to the first use of firearms in the Ottoman Empire (1354, 1364, 1386, and 1389) remain highly disputed. Most are mentioned only by single chroniclers who all wrote several generations after the event (Ágoston 2005:16). Nevertheless, the Ottoman conquest of Constantinople in 1453 illustrates that they did possess a keen sense of the power and importance that gunpowder weapons would play in the wars to come (Ágoston 2005:21). 1453 signaled the end of the Byzantines and the imperialization of the Ottomans. The sultan's immediate concern was to secure and organize his own power within the Ottoman State. Consequently, some of his first actions were directed towards reorganizing and re-centralizing the army and gunpowder production. With the fall of Constantinople a new militaristic Islamic state had appeared straddling the line between Asia and Europe, and it was strong enough to pose a serious threat to Europe on both land and sea.

The Ottomans were not the only state to recognize the importance of having an efficient gunpowder manufacturing industry and transportation network. In the 15th century, Venice's concerns over its supply of gunpowder were expressed by Giulio Savorgnan, who said that the lack of this war material was "the first and most important problem" facing the state. And that "of large [amounts] of gunpowder as of fine [quality], there is the greatest need" (Buchanan 2006:116). In the face of continuous Ottoman expansion in the Mediterranean, Venice increased its shipments of gunpowder to its outlying territories. For example, in 1567 the Venetian outpost at Cyprus was sent 60 tons of gunpowder, along with large quantities of cannon balls and 24 guns of different calibers. In the same year Crete received 30 tons of powder, along with over 20 new cannons (Buchanan 2006:115). This represented a huge expenditure for the republic that threatened to consume its complete reserve stock of gunpowder. Other European nations followed suit and in time developed their own gunpowder manufacturing capabilities. As time would show, the need to have adequate supplies of gunpowder on hand in a time of crisis would prove the decisive factor in a battle or even an entire campaign.

Methodological approach

In the literature today there exists an evolutionary explanation of European and Middle Eastern military changes during the course of the 10th-17th centuries. The Turkish archives contain a wealth of largely untapped information regarding Ottoman military practices, gunpowder production, gun casting, saltpeter mining, and shipbuilding. But despite this excellent primary source, only relatively recently have scholars begun using

it to research Islamic and Ottoman military technology. As a result, there is a host of misleading information about Ottoman military technology to be found in the secondary literature. Among these, the ideas regarding the Ottomans' technological inferiority and their supposed insufficient production capacity in gunpowder, munitions, firearms, and cannons, and the resulting dependence on imported European weapons and ammunition are the most widespread (Ágoston 2005:6).

From a methodological and theoretical point of view, this paper regards the mature literature of the New Military History as the most relevant. This approach is less concerned with strategy and tactics and instead places the focus on the operational processes and uncertainty in warfare. New Military History is not confined only to the study of sieges and campaigns; rather it takes into account various modes of production and transportation efficiency to distill a more accurate representation of the successes and failures in war. My research could not have been accomplished without the efforts by Ágoston, Murphey, and Quataert, all of whom have examined gunpowder and its manufacture and transportation in the Ottoman Empire in one way or another. While these works have proved invaluable to my research, they have often raised as many questions as they answered, and in the course of my research I came to support some ideas and question others.

Gunpowder manufacture and transportation in the Ottoman Empire

Although the Ottoman Empire experienced a period of tremendous prestige and power during the 15th and 16th centuries, it eventually followed the pattern set by all

empires throughout history: a period of expansion followed by a time of decline resulting in its ultimate demise. This paper looks at the reasons for the Ottomans' rise and decline through the perspective of the role of gunpowder, specifically in the manufacturing and transportation fields. Since gunpowder's invention, it has been a maker and breaker of people, nations, and empires. It is commonly accepted that cannons and firearms grew in power during the 15th-18th centuries until no commander or nation could hope to be victorious without gunpowder weapons. But one aspect that is commonly overlooked is that the reliability of the firearms, the training and skill of their operators, and the lethality of their shot, could all be undermined, and often was, by the quality and (often inadequate) explosive power of the gunpowder used in them. Gunpowder played a crucial role in determining the outcome of battles and sieges between the 15th and 18th centuries.

Evidence suggests that the Ottomans' early military success was in part due to their geographically favored position, which provided them with abundant natural resources. As a result of their large saltpeter deposits, the Ottomans were able to build up their gunpowder manufacturing capabilities swiftly and efficiently, much like an industrializing England was able to do with coal in the 1800s.

The Ottoman Empire also possessed an elaborate transportation network inherited from the Byzantine Empire, which included roads, bridges, and naval routes. Gabor Ágoston believes that by the mid-15th century, when the Ottomans' technological receptivity was combined with their munitions production capabilities and their superior transportation network, their armies gained a clear advantage over their immediate European neighbors, which they maintained until the end of the 17th century (Ágoston

2005: 9). It stands to reason that the Ottomans' later failures on the battlefield could in part be attributed to a change in the quality of the gunpowder their troops were using, due to several factors including manufacture and transportation.

It was the nature of the Ottoman administration to find an intermediate organizational solution with which it could exploit the manpower, skills, and resources of the various populations living within its borders, by enlisting local elements into the imperial way of life (Barkey 2008:150). Within the borders of their empire the Ottomans had abundant natural supplies of saltpeter deposits and wood for making charcoal, two integral components of gunpowder. They did not have to produce saltpeter in plantations as many European nations were obliged to do, and this gave the Ottomans an important initial advantage both in the availability of saltpeter and the quality of their gunpowder. This quality advantage in gunpowder could be quickly lost, however, due to the army's powder stores getting wet and spoiled, as happened in sultan Suleiman's campaign in the Balkans in 1529. His fortunes were reversed in 1543, when he launched a new campaign into the Balkans, putting into practice what he had learned from his previous mistakes, namely the extreme importance of a chain of supply depots well provisioned with high quality gunpowder and munitions for his army. Despite the Ottomans' initial advantages, they did suffer, along with their rivals, from issues with the manufacture of quality gunpowder. The problems of maintaining a consistently high standard of powder for use by their armies (especially before the corning process was introduced in the Ottoman Empire in the 1420s) led to several Ottoman defeats, such as the Battle of Lepanto in 1571, which shows that by the end of the 16th century the Ottoman gunpowder works

were not producing the same high quality power that had resulted in many of their earlier victories.

Another important factor that led to the Ottoman Empire's success was its method of transporting gunpowder to the front lines. Here their methods differed substantially from their rivals because they could utilize both land and sea routes for faster and more efficient transportation of supplies. This was made possible by the high priority given by the state to building and maintaining roads and ships. The Ottomans were favored by geography in that many of their theaters of war in the 15th through 17th centuries were easily accessible along major waterways, such as the Danube, allowing them to transport gunpowder quickly by boat as well as by land.

It was the Ottomans' efficient centrally organized manufacture and transportation of gunpowder in the period 1500-1700 that set them apart from their adversaries (Murphey 1999:99). We should not, however, overestimate the role early gunpowder weapons played in deciding military engagements. The change from the old European system where the cavalry dominated the battlefield to the new system imposed by firearm equipped infantry was slow to take root, and in some cases took not decades but centuries. Only the flexibility of the early Ottoman state, and the pragmatism of its rulers and military leaders, enabled it to be one of the first countries to assimilate gunpowder technology into their armies and be at the forefront of gunpowder manufacture and transportation (Ágoston 2005:21).

The Ottomans built and maintained a sophisticated network of gunpowder manufacturing plants spread across their empire that enabled them to provide timely and

reliable gunpowder to their troops on the front lines. Major concentrations of gunpowder works in the Ottoman Empire were restricted to areas which had ample manpower reserves, abundant natural resources, and proximity to waterways or roads for transportation.

The plentiful saltpeter deposits in the Ottoman Empire enabled it to concentrate its gunpowder manufacturing capabilities in several crucial areas, namely the Balkans, Anatolia, and Egypt. This meant that the gunpowder produced at these factories was never far away from where it was needed by the troops on the front lines.

The Ottoman Empire used water transportation, by sea or by river, which was often more expeditious than land transport and sometimes safer. For example, in the 16th and 17th centuries the frontier region of al-Hasa (in modern day eastern Saudi Arabia) was in constant need of supplies of gunpowder and munitions due to the hostility of the tribes in the area. As a result, the state and local authorities determined that these critical supplies should be delivered via the Red Sea rather than by land, both to circumvent the dangers of attack and to arrive more quickly. Transport by boat also carried risks. Gunpowder in the 14th century was extremely sensitive to moisture and would continue to be so until the invention of gunpowder corning was invented. If gunpowder came into direct contact with water it was instantly ruined. This necessitated great caution when transporting this crucial military material to armies at the front.

In contrast to water transportation, transportation by land relied primarily upon the labor of rented animals or the state's own ample imperial stable of draft animals. The Ottoman Empire developed a sophisticated and affordable transportation network for

moving large or small quantities of gunpowder speedily from their place of manufacture to wherever it was needed in the empire. The Ottomans benefited greatly from their internal lines of communication, both in Anatolia and in the Balkans, and were able to expand upon the road and bridge networks already in place during the late Byzantine Empire.

Religion

The many religious minorities living within the borders of the Ottoman Empire accelerated the adoption of technological innovations. *Dhimmis* (Jews, Christians, and other religious minorities), frequently spread new technology throughout the Ottoman Empire as they traveled abroad and brought back inventions and new ideas. But the Muslim majority was often reluctant to follow these innovators because it was widely believed that all non-Muslims must somehow be inferior, and therefore so must their ideas. Despite this religious stereotype, a great many Christians worked in armament factories throughout the Ottoman Empire, especially in Istanbul. A traveler, Nicolaos de Nicolay, who visited the Ottoman capital in 1551 noted that the Christian workers had "taught the Turkes… craftes and engines of warre, as to make artillerie, arquebuses, gunne pouder, shot, and other munitions" (Ágoston 2005:44).

Christianity in the West had a long history of opposing technological innovations which it saw as heretical or works of the devil. As one example, it was long believed,

though this is now contested,[1] that the crossbow was banned by the Second Lateran Council under Pope Innocent II in 1139 because it allowed anybody to kill a knight, upsetting the balance of power between peasants, knights, and clergy. In the early stages of gunpowder development, Christian authorities were vehemently opposed to the use of gunpowder weapons, calling them blasphemous and part of the 'Black Arts' (Norris 2003:12). During the mid 14th century, however, their opinion had changed, as it became apparent to the church that trained infantry armed with the guns could overpower the old feudal elite with its heavy cavalry. By the late 14th century, even the armies in the service of the Popes would be equipped with the latest in gunpowder weapons.

Industrial concentrations

Industrial concentrations in Ottoman territory were restricted to a few main regions due to several limiting factors. First, the Ottoman lands were generally sparsely populated, which led to a shortage of manpower for gunpowder works outside of the main cities. The Balkan provinces were the most populated; next was Anatolia, with only half of the Balkan population density, but with still had twice the density of the Arab provinces (Quataert 1992:6). A direct correlation exists between the availability of craftsmen and the location of munitions factories. Conscious of the shortage of craftsmen in certain cities, the state tried to bolster the manufacturing potential in Istanbul by sponsoring forced resettlement programs, known as *sürgün*, which were designed to draw

[1] See: Turner, Monte (2004). *The Not So Diabolical Crossbow: A Re-Examination of Innocent II's Supposed Ban Of The Crossbow at the Second Lateran Council*. Self-published thesis.

skilled laborers and craftsmen into the capital. During the reign of Selim I in the early 16th century, all the craftsmen in Tabriz were resettled in Istanbul, including 110 craftsmen specifically designated for work in the armaments and munitions industries (Ágoston 2005:44). Although it is difficult to determine the exact effect the resettlement programs had on the manufacture of gunpowder in the Istanbul factories, the fact that the state repeated the *sürgün* program several times throughout the 17th century makes it likely that it had a noticeable impact on the output of the gunpowder works.

Fortresses

In 1687, the Ottomans fortified the Acropolis in Athens for use as a gunpowder magazine. On September 26, when the Venetians under Francesco Morosini attacked Athens, a Venetian mortar fired from the Hill of Philopappus blew up the magazine, and the building was mostly destroyed (Mommsen 1941:554). To combat the risk of the gunpowder stores exploding during an attack, the Ottomans built several regional fortresses, such as Mosul and Buda, to a higher standard so that they would be more suitable for the storage of gunpowder and ammunition (Murphey 1999:18). Measures in these fortresses taken to protect gunpowder included thicker stone walls to create a drier environment for the sensitive powder and a minimal use of wooden beams to reduce the risk of fire if the gunpowder stores were hit by enemy attack.

Despite safety measures, gunpowder storage in fortresses continued to be a risky venture. For extended periods of time the chances were high that gunpowder would be spoiled by moisture or explode because of someone's carelessness. But under carefully

controlled conditions gunpowder could stay in a usable state for almost a decade. In April 1685, the state discovered that 300 *kantar*[2] (14.9 tons) of gunpowder, which had been delivered to the castle of Akkerman more than six years before during the Cehrin campaign, were still being stored in the castle. Upon realizing this, the commander Suleyman Pasha requested 250 *kantar* of this gunpowder be shipped to his army operating nearby because his supplies were running low (Ágoston 2005: 155). Properly stored gunpowder could be kept for use in an emergency for many years, and the Ottoman's strategically places fortresses constituted an important link in their supply network.

Technology transfer and diffusion

For centuries, the Ottoman Empire led the way in gunpowder technology innovations. Its advantage was due to the nature of gunpowder technology diffusion between the East and the West from the 15th through the 18th centuries. The Ottoman Empire was perfectly placed to gain the most from this technological transfer, located as it was at the crossroads of Europe and Asia, and benefitted from the knowledge of both sides. The Ottomans learned mining techniques from the medieval Balkan mining centers in Serbia, Bosnia, and Greece. Armenians also contributed their knowledge of mining and sapping, and from Anatolia and the Arab provinces craftsmen flocked to Istanbul who were skilled in metalworking techniques (including the forging of Damascus steel

[2] The common unit of measurement used in the Ottoman Empire. It is commonly held that 1 *kantar* = 99.05 pounds, or 45.02 kilograms.

(Verhoeven 2001:75)). In addition, the Ottomans drew heavily upon skilled Italian, German, French, English, and Dutch gun manufacturers and engineers to create the "ideal environment for technological dialogue" (Ágoston 2005:48).

The Ottomans invited skilled foreign technicians to work in their factories in order to keep up with European technological advances. Indeed, this was the primary method of acquiring new technology for both Europe and the Ottoman Empire between the 15th and 18th centuries. (Ágoston 2005:48). Since the 15th century, the Ottomans had relied heavily on foreign expertise and copied foreign models when manufacturing their own military and naval weapons. At the Imperial Cannon Foundry, or *Tophane-i Amire,* in Istanbul, the Ottomans employed as expert craftsmen many foreign nationals who were invaluable to the Ottoman understanding of European technological advances (Ágoston 2005: 45). The foundry employed forty to fifty Germans, and several French, Venetian, Genoese, Spanish, and Sicilian experts, who were paid directly by the state to oversee the training of other workers and the production of Ottoman arms and gunpowder (Ágoston 2005:45).

Technology transfer also benefited the Ottoman navy, which was the major means of gunpowder transportation. In the late 15th and early 16th centuries, the Ottomans acquired the common naval technology of the Mediterranean. The war galley remained the premier fighting ship of both the Ottomans and their Venetian and Spanish Habsburg rivals, though it was not suited to the transport of gunpowder because of its low sides and limited cargo space. Ammunition was transported in special ships, called gun ships (*top gemisi*) and stone ships (*tas gemisi*). For the transportation of gunpowder the Ottomans

used special “covered” (*ortulu*) boats. In 1488, and throughout the 16th century, the Ottoman fleet held ten gunships. From the data available we can surmise that during the 16th and 17th centuries the state had at its disposal vessels capable of transporting hundreds of cannons of various calibers, as well as their ammunition and supplies of gunpowder.

Corning

Around the mid 14th century, European gunpowder manufactures began adding liquid to gunpowder constituents, in order to reduce dust and the risk of explosion. The powder makers first moistened the gunpowder with wine, vinegar, urine or water, and then pressed the paste into “cakes” and let them dry. Once dry, the “cakes” were broken up into smaller clumps called “grains” or “corns.” Corned powder had a reduced surface area, which reduced the risk of it spoiling due to water. Prior to corning, gunpowder would gradually separate into its constitutive components and was too unreliable for effective use in guns. Gunpowder was also less prone to get damaged by overland transport, since vibrations of the wagon wheels would no longer separate out the different components. When the corned powder was lit, the flame would spread between the granules, lighting them all before significant gas expansion could take place. This resulted in greatly increased explosive power. Before corning, much of the powder away from the initial flame was blown out of the barrel before it burned.

The mechanical mixture of the ingredients was changed to a form in which the elements would not separate. Machines were then used to crush the clumps into kernels.

In pre-corning days, the sifting of the power during over land transportation resulted in a large variation in the explosive potential of the finished product. By more consistently approaching the optimum mixture in every sample, corned powder developed higher average breech pressures. In optimal firing conditions corned gunpowder could achieve far better results than noncorned powder. In practice this meant that the optimal conditions could be more frequently met with corned power because it was less likely to be damaged during transportation. The Ottomans successful early adoption of this critical improvement in producing gunpowder was demonstrated in their successful destruction by cannon fire the six-mile defensive walls around Hexamilion on the Isthmus of Corinth, which guarding the only land route into the Peloponnese peninsula from mainland Greece, in 1446 (Murphey 1999:107).

Some historians call the invention of corning the "military revolution" of the 1430s and 1440s, and maintain that this technology was so important that it dwarfed all other "revolutions" in military applications during the next 250 years (Murphey 1999:107). Murphey believes that changes made before the 1420s in the area of gunpowder production and effectiveness were far greater than those made from the 1450s onward, which were "both inconclusive and, in relative terms, insignificant" (Murphey 1999:108). After the introduction of corning the resultant increase in the penetrating force of gunpowder and firearms led to the increased importance of infantry troops armed with small arms. The Ottomans were very successful in adopting and integrating this new gunpowder technology into their armed forces and navy, and did it better at first than their immediate Christian and Muslim neighbors (Ágoston 2005: 57).

CHAPTER 2

MINERAL DEPOSITS

Like many of its European rivals, the Ottoman Empire declared the production of weapons, munitions, and gunpowder to be a state monopoly and took an active part in mapping out the resource deposits in the empire. The sultan claimed ownership over all the subsoil resources including the rights to iron, copper, salt, alum, and saltpeter. (Ágoston 2005: 104). Under sultanic decrees, the location and mining of saltpeter was usually handed to provincial and district governors (*beylerbeyis* and *sancakbeyis*). In the areas where it found saltpeter, the empire built and maintained large saltpeter works run either by state-appointed officials, or by members of the ruling elite who ran the plants within the *iltizam* or tax-farming system as entrepreneurs (Ágoston 2005:124). Mines were leased out to contractors who supplied the working capital, farming a mine as they would farm taxes from a town or village. The contractors took over mines for a period of several years, although contracts could be terminated prematurely if there was mismanagement or corruption (Quataert 1994:34). By maintaining tight control over the mining of gunpowder components the state guaranteed its absolute control over the production and distribution of gunpowder within the empire.

Saltpeter deposits in the Ottoman Empire

Gunpowder is a mixture of three elements: carbon, sulfur and calcium nitrate or, preferably, potassium nitrate, called "saltpeter." When the components are properly mixed, and the grain are kept dry, the rapid expansion of the burning sulfur results in hot gases (nitrogen and carbon dioxide) that produce a tremendous explosion, capable of propelling a projectile out of the barrel of a gun with enough force to topple castle walls (Kelly 2004:16).

Because of its abundant saltpeter deposits and effective production methods, the Ottoman Empire was able to out-produce its rivals in gunpowder quality and quantity in the 15th-17th centuries. The Ottoman lands were rich in natural saltpeter deposits, and unlike many European states, the Ottoman Empire was self-sufficient for all its domestic saltpeter needs. Northern Europe in particular did not possess the hot climate that helped decomposition occur quickly, or the long dry period that allowed nitrates to leech to the surface. The Middle East had both. Most European gunpowder makers had to search far and wide and often found only low quality, naturally occurring saltpeter deposits (Kelly 2004:33).

Prussia had to get most of its saltpeter from specially designed saltpeter plantations, whose yield was inferior to the naturally occurring Ottoman saltpeter. The plantations worked by mixing human feces, urine, the dung of horses, and lime obtained from old mortar or plaster together, and letting it stand covered from rain for a year. Saltpeter would then be produced as a white crusty powder described in contemporary sources as "snow" (Kelly 2004:35). The amount of saltpeter produced in Russia in the

15th and 16th centuries was more than sufficient for domestic needs, as large quantities of it were sold to Denmark in 1518. But reports in 1589 made by the English Muscovy Company suggested that the quality of this saltpeter was inferior to that of the rest of Europe (Esper 1969:194).

Early in the 15th century, the Ottomans produced saltpeter near Üsküp and Priština in the Balkan provinces, and from the mid-16th century many new production centers in the Balkans opened up: the *sancak* of Silistre, the villages of the district of Cirmen near Edirne, which also had the advantage of being close to the Maritza River. Later in the 16th century Filibe, Tatarpazr, and the area around Hirsova, a village on the banks of the Danube in the *sancak* of Semendire, became major producers of saltpeter as well (Ágoston 2005:98). In Anatolia the main saltpeter production center was at Karaman, where thirteen production facilities were in operation by the early 1570s, producing more than 40% of the total output of all Ottoman saltpeter mines.

The Ottomans were quick to make the most of their natural advantage of saltpeter deposits. They established several gunpowder mills, and built and maintained roads for the transportation of saltpeter to them. In Anatolia, saltpeter mined around Karaman was loaded into wagons and transported to one of several gunpowder manufacturing plants (*baruthanes*) for processing into usable gunpowder. These plants, built in the 16th and 17th centuries, were primarily located in or near major cities. The raw saltpeter was loaded into wagons and placed in special water resistant animal skins. Every effort was made to keep it dry and transport it to the plants quickly.

When the wagon loads of saltpeter arrived at the plants, professional craftsmen mixed the components, grinding all three together to make gunpowder. The finished product was then carefully stored in special weather tight barrels in cool, dry storage rooms underground and either kept there temporarily or immediately shipped to a forward storage depot.

The Ottomans used several methods of gathering enough saltpeter to feed its gunpowder mills throughout the empire. The two most common forms were state-run workshops run within the tax farming system. The other was the production of saltpeter by service or *ocaklik* villages in return for tax and military exemptions. In exchange for their service of supplying the state with the necessary resources, the villages were exempt from the extraordinary wartime taxes known as *avariz* (Ágoston 2005:105).

The tax farming system was not perfect, however, as the Halil Revolt in the 1730s illustrates. Patrona Halil was a soldier and artisan who led a group of disgruntled merchants and traders to rebellion against the state in September 1730. They were angered by the imposition of the extraordinary campaign taxes, to pay for the war with Iran, which was placed on top of the special war mobilization tax (*ordu akcesi*) already in effect. The rebels demanded the execution of the grand vizier Nevşehirli Damat İbrahim Pasha whom they blamed as the agent of their misery (Barkey 2008:216). In response to their demands, the state quickly carried out his execution. In October, however, Ahmed III was deposed and replaced by Mahmud I, who repealed most of the taxes. The Halil Revolt suggests that by the 1730s the tax farming system and the imposition of war taxes were overexploited (Barkey 2008:271). The bureaucracy had worked its way into a trap

that would lead to the destabilization of their revenue sources as well as the decline of their gunpowder industry. The Ottoman Empire was not the only state to overburden its tax-paying peasantries to pay for war, state building, and extensive public construction. Both France and the Hapsburg Empire were in similar straits. All three states tried to find a balance between strengthening the central administration and giving enough independence to the provinces (Quataert 1994:43).

The men who mined saltpeter were usually small independent farm owners who worked in the mines on a part time-basis. In the 16th century the state experimented with employing laborers who had no ties to agriculture in the province of Erzurum, but in the end decided it was best to employ small independent landowners who could work off their obligations and stay on the land. A similar scenario prevailed in 17th and 18th century Europe, where peasants who lived in areas too naturally poor to survive by farming supported themselves by rural industry (Quataert 1994:35). Locals transported the raw mined material from its place of origin to the factories that needed it. This was often done by road to lessen expenses, and when water transport was unavailable. (Quataert 1994:35).

Saltpeter was not only produced in the core Ottoman provinces, but also in other strategically important areas. Egypt was important for economic, strategic, and religious reasons, accounting for a third of the Empire's revenues by that late 1520s (Ágoston 2005:146). Its ports were perfectly located in the eastern Mediterranean, and it served as the main Ottoman naval base to ward off Spanish or Venetian attacks. It was also a historic center of Islamic culture. A revolt in 1523, led by Ahmed Pasha acted as a

warning to the state that Egypt would need a strong military presence if it was to be controlled. This presence could only be maintained by an army with a sufficent supply of gunpowder, and by the mid-16th century, the state had co-opted in Egypt seventy villages to produce saltpeter for the *baruthane* (gunpowder works) in Cairo (Ágoston 2005: 99). By the mid-16th century, the *baruthane* in Cairo was a major producer of gunpowder for the Ottomans, preparing 216 metric tons for the Malta campaign in 1564. In the late 16th and early 17th centuries this amount rose, as Cairo exported 378 metric tons of powder to be used in the Hungarian wars of 1593-1606 (Ágoston 2005:147).

The Ottoman state carefully managed all aspects of the safe and efficient transportation of critical war time supplies, such as gunpowder and its various components. The state took saltpeter collection so seriously, that in 1572 it rescinded a *mübayaa* (the form of purchase by which the Ottoman administration secured a wide variety of draught animals) on camels in the area of Akdağ (Madeni). Due to the populace hiding their animals from the state's agents, the local kadi had been unable to hire enough camels to transport a consignment of saltpeter to Istanbul for production. With the *mübayaa* lifted, the transportation of the vital war material was able to proceed (Faroqhi 1982:528).

Saltpeter deposits in Europe

In Europe, the difficulty of gathering sufficient quantities of high quality saltpeter was a major handicap during the early days of gunpowder production. Europeans came up with a method of acquiring enough saltpeter to fuel their gunpowder mills by scraping

off the “salt of stones,” (or the white crystals of raw saltpeter) from privies and stables, where it was a natural byproduct of human and animal excrement. Specially trained “powdermen,” armed with royal warrants, searched the countryside looking for manure piles, old cesspools, and stables from which to collect the precious substance (Kelly 2004:34). Although this method yielded a small amount of saltpeter, it was not enough to fuel Europe’s rapidly expanding munitions industry in the 14th century. Realizing this, craftsmen in the late 14th century began to experiment with artificial saltpeter. They trapped the runoff of nitrate salts from organic material in large and well-organized saltpeter plantations. The first record of one such plantation is in Frankfurt in 1388 (Kelly 2004:35). Prussia later developed some of the most sophisticated plantations for artificial saltpeter production (Kelly 2004:164).The rapid spread of these plantations facilitated the growth of Europe’s gunpowder manufacturing industry and paved the way for further innovations in gunpowder weapons.

The western saltpeter plantations provided Europe with more saltpeter than it had before, but the gunpowder mills in Europe still had to have hundreds of pounds of saltpeter scrapings from the plantations in order to produce just half a pound of refined saltpeter that could be used in gunpowder (Kelly 2004:35). The Ottomans, on the other hand, did not have to rely on artificial saltpeter production and required much less of their naturally-occurring saltpeter to produce gunpowder. The Ottoman Empire had an abundant supply of the best kind of saltpeter for manufacturing gunpowder – found only in nature – was potassium nitrate. In this, Europe was at a great disadvantage. The nitrates produced in Europe using the plantation method were composed of calcium.

They were efflorescences caused by the oxidation of nitrogenous matter in the presence of alkaline substances, such as urine. Calcium nitrate could be used in gunpowder to produce explosions on par with potassium nitrate, but it absorbed water from the air at a much quicker rate and was therefore ruined much more easily than gunpowder made with potassium nitrate.

Sulfur and charcoal deposits in the Ottoman Empire and Europe

Sulfur was not available in the Ottoman lands in such ample quantities as saltpeter. It came mostly from the land around the Dead Sea, the province of Van in eastern Anatolia, and the Island of Melos in the Aegean Sea. In the Balkans, sulfur was mined in Macedonia, especially the villages in the region of Ohrid, which were the main suppliers of sulfur to the gunpowder factory in Istanbul (Ágoston 2005:100). The methods used by the villagers for extracting sulfur from ore were very inefficient, sometimes destroying ten times more sulfur than they actually produced (Ágoston 2005:101). Even so, calculating that Ottoman imperial campaigns in the late 17th century required about 540 metric tons of gunpowder and that the sulfur proportion in gunpowder was around 13-15 percent, the village producers in the Balkans supplied between 40 and 50 percent of the sulfur required per year.

The state showed keen interest in locating all potential sources of sulfur and encouraging the production of high quality gunpowder. From the 16th century onwards, the region around Lake Van was the main sulfur-producing region in the eastern part of the empire. When a report in 1570 stating that 108 metric tons (2,000 *kantar*) of sulfur

had been produced at a mine near Lake Van in the *sancak* of Hakkari, the state gave orders that it should be transported over land on hired draught animals to Trabzon, and from there placed on ships to carry it to the gunpowder works in Istanbul (Ágoston 2005:101). Even when the state discovered that the real amount of sulfur produced was only a quarter of what had initially been reported, and that the cost of transporting it was going to be very high (11 *akcas* for every 23 kg of sulfur), the state still insisted on its immediate transportation to Istanbul, so valuable was this resource for the war industry (Ágoston 2005:102).

The state's need for raw materials sometimes led to corruption because of the exemption for those working in the armament industry from the irregular wartime tax called the *tekalif-i orfiyye*. Many towns and villages undertook contracts for sulfur mining to escape the wartime tax that they knew they would be unable to fulfill. For example, in 1572 the village of Leskofce in the region of Ohrid was charged to produce 8,100 kg (150 *Kantar*) of sulfur per year in exchange for exemption of the *tekalif-i orfiyye*. Authorities later discovered that there were no sulfur deposits in the lands belonging to the village, and furthermore that the inhabitants had no knowledge of how to extract sulfur from ore (Ágoston 2005:101). Central authorities were never able to completely put a stop to corruption in Ottoman gunpowder manufacturing.

In Europe, sulfur was found in only a few volcanic regions, most importantly Sicily, which supplied the entire continent in the early modern era. The sulfur from Sicily was not of a high quality, as it was mixed with limestone, and was usually only 20 to 40 percent pure (Ágoston 2005:100). In addition to sulfur and saltpeter, charcoal also had to

be purified in order to produce gunpowder. Charcoal had long been used by Europeans for cooking and metal work and was abundant across much of Central and Northern Europe (Kelly 2004:33). However, the area around the Mediterranean had experienced steady deforestation since the Romans had harvested lumber for construction and ship-building in the first century BCE, and sufficient wood was hard to come by.

All charcoal is made out of soft wood with as much pith as possible. Woods that are thin, young, and without hard knots are best for this. Charcoal was produced similarly in the Ottoman Empire and Europe by heating wood in airtight ovens or kilns supplied with limited and controlled amounts of air. Wood exposed to high temperatures broke down into gases, a watery tar mixture, and a solid black carbon material referred to as charcoal.

The Ottomans produced charcoal from wood that was called *kara agac* (black wood), which they understood as wood from non-fruit-bearing trees, such as the willow and the poplar (Ágoston 2005:103). To ensure a steady supply of high-quality charcoal, the state forbade the unauthorized cutting down of willow trees within a few miles of any state run charcoal burner. Europeans made charcoal from several types of wood, including alder, dogwood, willow, oleander, yew, hazel, and hemp stems and vines. The selection of wood depended on climatic differences from one region to another. In general all gunpowder producing countries in Europe harvested wood in the spring, when its sap contained less inorganic matter and then left it to dry for 18-36 months (Ágoston 2005:103).

As with gunpowder, the storage of charcoal requires special care, because without proper protection from the elements moisture can ruin large quantities in a short amount of time. For example, in the 1560s an entire storehouse of charcoal near the *baruthane* of Istanbul was ruined due to rainwater leaking in. After an investigation into the cause it was determined that improper construction of the building led to the leak. During the reign of Mehmet, improved safety measures were taken to ensure that gunpowder, and all its components, were stored with the utmost care (Ágoston 2005:104).

CHAPTER 3

MANUFACTURING GUNPOWDER IN THE OTTOMAN EMPIRE

Gunpowder mills in the west

The Ottoman Empire built its major gunpowder works in the 16th and 17th centuries, located in Istanbul, Cairo, Baghdad, Aleppo, Yemen, Buda, Belgrade, and Temeşvar. From the 15th-17th centuries they produced enough power to meet the empire's needs. Smaller gunpowder manufacturing plants were located in Erzurum, Diyarbekir, Oltu and Van in Anatolia, and Pécs in Hungary (Ágoston 2005:128). Apart from these gunpowder works, smaller mills were located in many of the major fortresses across the empire, providing for the needs of the local garrison. Central authorities closely regulated the entire process of collection, manufacture, and transport of gunpowder. The state was continually pushing for improvements in both the quality and quantity of gunpowder in order to meet the expanding demands of its army and navy.

Many Ottoman gunpowder mills had to obtain their sulfur from distant sources due to insufficient local production. For example, gunpowder mills in Ottoman Hungary brought in sulfur from other parts of the Empire as far away as eastern Anatolia (Ágoston 2005:102). Any surplus raw materials and excess gunpowder were sent to Istanbul for storage and redistribution to other munitions locales. For example, the *baruthanes* in

Iznikmid transported over 1,000 sacks of charcoal to the gunpowder works in Istanbul between 1698 and 1699 (Grant 1999:194).

The majority of these *baruthanes* in the Ottoman Empire were stamp mills, which housed anywhere from five to fifty, or sometimes more, mortars and pestles to grind saltpeter, sulfur, and charcoal together into gunpowder. The mortars were typically constructed out of bronze, but they could also be made of wood. These large mortars gradually gave way to smaller versions with capacities ranging from 20-25 kg, which were less likely to break and cause explosions. The continual need for increased production capability throughout the 15th-17th centuries led to the expansion of virtually all of the empire's gunpowder works. In 1567, the gunpowder works at Buda operated with 20 large mortars, each with a maximum capacity of 61-688 kg (50-55 *okka*), but by 1577 the Buda works had 44 large and small mortars in operation (Ágoston 2005:151).

Once the finished gunpowder left central storage depots, there was high risk of it being damaged en route to its destination at the frontier. Even in optimal dry weather conditions, the fording of rivers, an unavoidable necessity of logistics in all military campaigns was a serious obstacle to the safe arrival of the powder. For example, in 1630, the siege of Baghdad failed due to fresh stores of gunpowder getting wet at the fording of a minor river, jeopardizing the success of a major army mobilization (Murphey 1999:15).

In order to supply their advancing armies with gunpowder in the wake of the Ottoman conquest of the Balkans in the 14th and 15th centuries, the empire established a series of gunpowder mills in the newly acquired lands. Because existing flour mills in the Balkans were already of the right size, and contained mortars and pestles that could be

easily converted to produce gunpowder instead of flour, they were transformed into gunpowder plants. The state favored these conversions instead of building new mills in order to save time and money. Priority was given to local gunpowder manufacture because it was cheaper and quicker to transport the powder to Ottoman forces and fortresses at the front. Ottoman campaigns in the 16th and 17th centuries consumed on average 400-500 metric tons of gunpowder per year (Ágoston 2005:135). The state brought its master craftsmen from Istanbul to carefully supervise the conversions with strict guidelines as to how the plant should be organized. This high level of oversight allowed the state to maintain a degree of control over the quality of the powder produced in the far corners of the empire.

Of the frontier gunpowder works, the *baruthane* at Buda was the most significant. It sat on a major port on the Danube and was an important supply depot during all the Ottoman campaigns against Russia. The Buda works were designed to provide 200-300 *kantars* to the three other fortresses in Hungary and another 500 *kantars* annually to the Belgrade arsenal (Grant 1999:194). In the 1570s, the Buda works produced about 1,000 *kantar* (54 metric tons) per annum and supplied a substantial percentage (54-162 metric tons) of the region's fortresses with gunpowder, as well as suppling the Mediterranean Ottoman fleet as it combated the Venetians in 1593. The Buda mill was also the largest storehouse of gunpowder in the Balkans, holding 10,000 *kantar* (540 metric tons) of gunpowder according to a 1684 inventory (Ágoston 2005: 136).

The *baruthane* at Baghdad operated to supply 1,000 *kantars* annually to Istanbul via the Aleppo road (Grant 1999:194). The *baruthane* at Kagithane, the main Ottoman

gunpowder factory in Istanbul, was the first industrial activity in the region and dated back to the Ottoman sultan Bayezid II (1481-1512). Kagithane was perfectly located to receive supplies of raw materials from the far-flung corners of the empire, situated as it was at the junction between the east and west portions of the empire. Kagithane produced seventeen tons of powder per month in 1571 (Grant 1999:194). Istanbul was also the main departure point for galleys heading into the Black Sea carrying gunpowder to supply the Ottoman armies against Hungary, Poland, Russia, and the Safavid Empire. Istanbul was the base for the main Ottoman navy and had ample manpower resources. All of these factors led to this *baruthane* being the most important in the empire. Furthermore, the rooms beneath the domes of the Theodosian walls offered a safe location for the storage of gunpowder manufactured in Istanbul or brought there from other parts of the empire (Ágoston 2005:128).

In Anatolia, the foremost gunpowder factory was the *baruthane* of Bor located in the province of Karaman (also a major center of saltpeter production). In the 1630s the *baruthane* of Bor produced 110 metric tons of gunpowder per annum. By the late 1640s, due to increasing numbers of mortars and pestles, production increased to 162 metric tons for a time. During years when the Ottomans were not engaged in any major campaigns, the output level in plants such as Bor dropped. In the 1650s, Yakub Efendi, the manager of the plant, was accused of corruption and stealing funds, and the output of the *baruthane* dropped to its lowest levels in years, hampering the Ottoman stockpiling of surplus gunpowder in peacetime (Ágoston 2005:143). During the 1670s, the *baruthane* of Bor received insufficient supplies of saltpeter from local saltpeter-producing villages, due

to continued corruption and neglect (Ágoston 2005:144). As a result, production in the Karaman province declined, and it appears that gunpowder production at Bor came to an end by 1694-95 (Ágoston 2005:144).

Water vs. horse power

The Ottomans used a mixture of water and horse power to run their gunpowder mills. They preferred to use water to drive the pestles, like those at Buda and Egri, because it was more cost effective. Water was not available in many locations, and there the Ottomans used horses to drive the wheels of their powder plants. This strenuous task was often carried out by teams of horses over 100 strong in one mill. The death rate for these animals was extremely high. For example, the gunpowder works located in Istanbul employed 100 horses by the late seventeenth century. In 1690 alone, 35 of these horses died from exhaustion, and between 1697 and 1700, 69 out of 92 horses died (Ágoston 2005:151). The gunpowder mill at Bakirkoy was originally built to harness water power to drive its pestles, but eventually converted to horse power for greater efficiency (Ágoston 2005:151). By harnessing both the power of water and horses to drive the wheels of their gunpowder mills, the Ottomans produced a steady flow of gunpowder and easily out produced their rivals in the 16th and 17th centuries.

Gunpowder mills in the east

After the "Two Iraqs" campaign and the conquest of Baghdad by Suleiman in 1534, Baghdad became the center of gunpowder manufacture in the eastern Ottoman

Empire. The state was acutely aware of the great distance separating Istanbul from Baghdad, and the unstable nature of its relationship with the Safavids in Iran. It accordingly placed great emphasis on turning Baghdad into a center of self-sufficiency for the state's entire eastern theater of operations. The most important step in this plan was to establish the *baruthane* of Baghdad near the Shaykh 'Umar gate of the city, which was operating at its full annual capacity of 270 metric tons (5,000 *kantar*) by 1566 (Orhonlu 1984:132). This supply was more than the eastern theater required, and in the mid 1570s 105 metric tons (2,000 *kantar*) of gunpowder were transported annually to Istanbul and the European theater by the navy via Tripoli and Rhodes.

Despite a promising production rate, the gunpowder works at Baghdad experienced quality control issues in its early years which led to several setbacks on the Ottoman military front. Cauldrons used in the distillation and refinement process became worn and needed repairs, and the entire plant had to shut down several times while they were mended (Ágoston 2005:149). Repairs were complicated due to the lack of local copper and lead of adequate quality, which had to be brought from central Anatolia. There was also a shortage of quality wood necessary for the fires that heated the cauldrons for the gunpowder recipe. The Ottomans eventually found enough wood in the province of Şehrizor to the north, and transported it to Baghdad along the Tigris and Euphrates (Ágoston 2005:149). During the time these repairs were underway the gunpowder turned out by the *baruthane* of Baghdad was not of consistent quality. This was particularly disastrous for the Ottomans in the Battle of Lepanto in 1571, as Baghdad was the main supplier of gunpowder to the Ottoman fleet.

The military preparation preceding the Battle of Lepanto required the Ottomans to gather together large quantities of gunpowder. In April 1570, the commander of Baghdad was ordered to send 3,000 *kantar* of gunpowder to Tripoli (Tarablus al-Gharb) by camel (Ágoston 2005:148 footnote 80). This gunpowder from the *baruthane* of Baghdad was of poor quality, due to the problems experienced at the mill in the late 1560s and in 1570. It is possible that the navy did not know of the powder's unreliability at the time, but in any case it was transported by boat to Cyprus, and used on October 7, 1571 at the Battle of Lepanto. This battle took place between the main fleet of Ottoman war galleys and a galley fleet of the Holy League (a coalition of Spain, the Republic of Venice, the Papacy, the Republic of Genoa, the Duchy of Savoy, and the Knights Hospitaller). Their goal was to deny the Ottomans dominance of both the western and eastern Mediterranean. The fleet of the Holy League was composed of 6 galleasses (a new type of ship with more room for artillery) and 206 galleys. Ali Pasha commanded an Ottoman force of 222 war galleys, 56 galliots (smaller galleys), and some minor vessels (Guilmartin 2003:224).[3] All members of the alliance viewed the Turkish navy as a significant threat, both to the security of maritime trade in the Mediterranean Sea and to the security of continental Europe itself.

Niccolò Capponi, a highly regarded Italian Renaissance scholar with a focus on military history, has given a detailed description of the role gunpowder played in this pivotal sea battle. The Europeans carried an important and decisive advantage because of their numerical superiority in guns and the superior quality of the gunpowder aboard their

[3] Agoston puts the total number of ships in the Ottoman navy at 260 (49).

ships. Parker estimates that the Christians had 1,815 guns, while the Turks had less than half that number with insufficient ammunition and gunpowder supplies (Parker 1996:89).[4] Sources indicate that the Ottoman galleys were running short of gunpowder just two hours into the four hour engagement, and that the gunpowder they had was unreliable. In the heat of battle spoiled gunpowder supplies meant that cannons could not be discharged and muskets could not be fired (Capponi 2007:157). This greatly undermined the effective fighting potential of the Ottoman fleet as well as decreasing morale amongst their forces. Furthermore, the poor quality of the Ottoman powder that did explode created a thick grey smoke on board their ships, which obscured their archers' view and prevented them from aiming accurately at the enemy ships (Capponi 2007:339). The battle concluded after about four hours of frantic fighting. The Ottoman fleet suffered the loss of about 210 ships, including 117 galleys. On the European side 20 galleys were destroyed and 30 were damaged so seriously that they had to be scuttled.

Capponi concludes that the European fleet made better use of its gunpowder weapons than the Ottomans and utilized its new type of warship, the galleasses, which were higher and larger than regular galleys, and whose heavy artillery allowed the European seamen to prevent the Ottomans from utilizing their superior boarding tactics (Capponi 2007:398). Ten years later, in 1581, Spain and the Ottoman Empire signed a truce that effectively suspended organized naval warfare in the Mediterranean. The struggle was never officially resumed, although state-supported pirate vessels continued

[4] The number of Turkish guns is said to be deduced from lists of booty after the battle. These lists are unlikely to be complete.

to sail in Mediterranean waters for several centuries. These vessels were increasingly of the larger cannon-carrying galleon design, and began to dominate both trade and piracy in the Mediterranean from the beginning of the 17th century as the use of the war galley declined.

With the lessons learned from the Battle of Lepanto, the Ottomans decided to initiate measures to improve their gunpowder production. In 1794, under the leadership of Tevki'i al-Ratik Efendi, the Ottoman Empire decided to modernize its existing powder works. The state ordered European equipment for the *baruthanes* at Bakirkey, Gallipoli, and Salonika. The state's goal was to increase production to 5,000 *kantars* of powder per year. Despite these efforts, production did not increase as much as expected, although subsequent efforts provided greater increases in production (Grant 1999:196). In 1795 a group of British gunpowder experts along with Mehmet Oerif (*Şerif* Efendi) rebuilt twenty old mortars and pestles at the Bakirkey gunpowder works and installed five new ones. As a result, production at Bakirkey nearly doubled from 1,500 *kantars* of old powder to 3,000 *kantars* of European powder. Further efforts to reform gunpowder production were carried out at Gallipoli and Salonika, and the state invested in building a new gunpowder mill at Azadli on the Sea of Marmara. This factory employed water power instead of animal power and for that reason was able to produce high quality gunpowder at less cost than other mills. Due to Azadli's successes, after 1797 the works at Bakirkey was shut down and served only as a storage depot, and the plants at Izmir, Salonika, and Gallipoli were closed completely (Grant 1999:196). After 1795 the

Ottomans could produce sufficient quantities of powder domestically, and they became completely free of imported powder.

Minor and frontier gunpowder mills

In addition to its major gunpowder mills, the state built an important network of minor gunpowder works. It constructed them relatively close to the places their gunpowder would be needed, due to the high costs and risks involved in transporting gunpowder across the empire. Although the minor gunpowder mills averaged only 54 metric tons per year, they represented an important link in the Ottoman gunpowder manufacture and transportation network (Ágoston 2005:149).

Of the minor gunpowder works in the east, which included Erzurum and Van, Aleppo was the most important because it was located relatively close to the Mediterranean and had a sufficient supply of local manpower (Ágoston 2005:149). In 1570, the commander of Aleppo was ordered to make 54 metric tons (1,000 *kantar*) of gunpowder and transport it to Cyprus in preparation for Selim II's Cyprus campaign, which he was able to produce and deliver in time. The minor gunpowder works were an important component to the Ottoman's commitment to supply its forces with the closest gunpowder available.

By the 16th and 17th centuries, the wide availability of gunpowder and small arms led increasingly to banditry. A chain of rebellions in the Ottoman heartland against the state's authority (the Celali revolts) frequently disrupted the road network and gunpowder transport in Anatolia. The empire could no longer ensure the safety of merchants, who

were obliged to negotiate safe passage with the leader or warlord of the area in which they were traveling, or safely transport gunpowder. Not until the 18th century did the state's efforts to improve the safety of the roads, by establishing a corps of pass-guards, succeed in freeing land transport in Anatolia from bandits and highway robbers (Faroqhi 1982:45).

The Ottoman Empire attempted to curtail banditry across their provinces by issuing several decrees to strengthen the state monopoly on the manufacture of gunpowder and firearms. The first such decree was the *Kanun-name* of Egypt, issued in 1524, that said, "the manufacture of and trade in *fufeng* (muskets) was proscribed, and possession was punishable by death" (Buchanan 2006:54). *Celalis*, or bandit-mercenaries, plagued the Anatolian peninsula from 1550s-1650s, causing major revolts in 1526-28, 1595-1610, 1654-55, and 1658-59 (Barkey 2008:175). These were especially prevalent in the empire's south-eastern frontiers. The major uprisings involved the *sekbans* (irregular troops of musketeers), who during wartime served the governors and drew regular pay, but in peacetime were not disbanded without pay and resorted to banditry.

The widespread prevalence of gunpowder weapons increased the menace of these groups, and the state's inability to retain control over the muskets in the hands of the *sekbans* was a serious mistake. The chaos c*elalis* caused in Anatolia led the state to the bargaining table as the quickest means of putting an end to their rebellions. The state often cooperated with the leaders of such groups, sometimes going so far as giving official jobs to the leaders if they would reassign their men to peaceful pursuits. The

state's response to the bandits was an attempt to achieve centralization through negotiation and absorption, a method that Russia also used with Cossacks at the edges of its empire (Barkey 2008:179).

Accidents

Manufacturing massive quantities of gunpowder in plants with little or no safety regulations was extremely dangerous. Accidents in the Ottoman *baruthanes* were common, the worst resulting in the complete destruction of the plant and all of its powder stores, often with a staggering loss of human life. In 1685 a fire that broke out in the *baruthane* of Izmir destroyed 32 *kantar* of gunpowder (Ágoston 2005:145). Accidents were common during the overland transport of gunpowder as well, when the excess of friction caused by the jarring of a wagon wheel against a stone, or a moment's forgetfulness with an unattended candle, could spell instant disaster (Kelly 2004:178).

During the siege of Athens the Acropolis suffered from continuous bombardment for eight days, and on September 26, 1687 a Venetian mortar shell scored a direct hit on the Parthenon that the defending Turks were using as a storage magazine for their gunpowder. The explosion tore apart the walls of the Parthenon, and the resulting fire burned for two days and left the building in the destroyed state we see today (Dontas 1979:16).

Manufacture summary

Achieving optimal results, even from the best weaponry, was dependent on the quality and quantity of the gunpowder available to each opposing army in a battle. Because of the nature of gunpowder mining and production in the Ottoman Empire, scattered as it was between many locations throughout the Balkans, Anatolia, and further east (from Buda to Konya), maintaining a consistent standard both in the raw material used and in the finished product was virtually impossible. Even more critical than issues of quality control was the problem of safe storage and transportation of the finished product. The “shelf-life” of gunpowder, even under the most optimal storage conditions, in the 14^{th}-17^{th} centuries was poor at best.

CHAPTER 4

TRANSPORTATION OF GUNPOWDER IN THE OTTOMAN EMPIRE

The Ottomans judged supplies and logistics to be the wartime factors most likely to determine success or failure (Murphey 1999:101). This was shown during the Ottomans campaign of 1711 against Peter the Great's army on the banks of the Pruth River. Sir Robert Sutton, the British ambassador to Istanbul from 1710-1714, reported that, "The Muscovites did not lose above 800 men in the attacks [by the Ottomans and their allies], but the sicknesse was so great among them that there died 300 or 400 men daily" (Kurat 1953:66). This sickness was made worse by inadequate food and water supplies in the Russian camp. The problem of supply was one to which the Ottomans paid careful attention. Indeed, observers of the Ottoman Empire frequently made note of its abundance of military supplies, such as gunpowder, and its skill and capacity for transporting them as one of the reasons for their success (Finkel 2007:122).

The Ottomans were unique among all their rivals in the 15^{th}-16^{th} centuries in that they grasped the importance of having a comprehensive system of storage depots strategically placed throughout their empire. The Ottomans built and maintained a sophisticated network of depots for the storage of gunpowder, along with munitions and other military supplies along the central highway system (known as the *menzil-hane* network), which linked their European and Asian provinces. However, the *menzil-hane*

network was of little use to armies operating in hostile territory, such as Hungary, because the Ottoman army could not build and maintain roads in territory which it had not yet consolidated. While the army was beyond the reach of the Ottoman's central road network, it relied on massive numbers of transport animals, especially camels to transport its supplies. During the campaign to recapture Baghdad in 1638, the army required about 140 tons of barley each day for animal feed alone. Assuming a full barley ration of ten pounds per horse was given daily, 140 tons was only enough to supply a small percentage of the army's mounts (Murphey, 1999:70). Despite these challenging logistical problems, the Ottoman Empire was able to conduct successful campaigns on both its eastern and western borders, sometimes simultaneously, by drawing upon its vast human and animal resources.

The delivery of cannons, armaments, and gunpowder to the Ottoman troops in the field represented another critical consideration for the Ottoman Empire. Regional storage depots, such as the one at Belgrade, were the state's solution to facilitate the swift movement of munitions to the place where they were needed. In the areas of transportation and logistics, "the Ottomans were the trend-setters and models of perfection whom the others [Europe and the Ottoman's eastern neighbors] strove to emulate" (Murphey 1999:99). The centrally organized and efficient manufacture and transportation of gunpowder in the period 1500-1700 was the feature that most distinguished the Ottomans from their contemporary rivals and corresponded with low transportation costs.

The state kept its own imperial herds of transport animals, including camels, buffalo, mules, and horses. However, the number of animals the state could maintain was insufficient to meet peak demand during wartime, so it relied heavily on supplementary services provided by private individuals or organizations (Murphey 1999:79). The state contracted to hire animals with their owners at fair market rates. In the 1690s, the cost was just 0.0284 *akces* per kilometer on the 705 kilometer route between Belgrade and Edirne. Though this route passed through provinces with well maintained roads, transport to the outer provinces might cost 30 or 40 times this amount (Murphey 1999:78).

The state run *menzil-hane* road network was more advanced in scale and reach than any of the transportation networks of the Ottomans' European rivals' (Murphey 1999:98). In Europe, until the reign of Louis XIV in France (1638 - 1715), most countries lacked any road network that could remotely compare with the efficiency of the Ottoman network. It was only under Louis XIV that storage depots (*étapes*) were set up in France, and no serious measures to standardize transportation for critical military supplies, like gunpowder, were taken in Europe until the 18th century (Murphey 1999:99). The slowness of European powers to standardize and streamline their military transportation system gave the Ottomans several centuries (from the 1400s-1700s) in which they had the advantage in military logistics and supply.

Roads

By the early 1600s, roads in the Ottoman Empire, especially the major highways between Istanbul and the frontier provinces such as Buda and Baghdad, were carefully

maintained by the state. In the Balkans, the roads between Belgrade and Buda on the northern Hungarian frontier were maintained to high standards, in large part to facilitate the rapid movement of troops and munitions from the regional supply depots to the front lines. In Anatolia the Ottomans had inherited from the Selçuk Turks and the Byzantines a network of caravanserais[5] along with the roads that linked them together. It was in the interest of the state to ensure the safety of couriers and military convoys, and for that reason it extended the caravanserai network further into the Balkans in Ottoman times.

Like many other early modern states, the Ottoman Empire had difficulty in getting tax-payers to pay with cash, and what cash the treasury did have was usually spent on paying the army (Quataert 1994:15). Until the later part of the 16th century Ottoman finances were relatively strong due to its rapid territorial conquests (Pamuk 2004:85), and it had sufficient cash to pay for military expenses. In contrast to the 16th century, most economic historians agree that the 17th century was distinguished by a period of financial crisis as increased trade between Europe/Ottoman Empire and India/China drained silver eastward (Ozmucur 1996:296). As fiscal difficulties began to accumulate the state resorted to short term borrowing from high ranking officials, as well as the sultan, to pay the military budget during times of crisis or war (Pamuk 2004:85). By the 18th century, the empire entered a period of comparative stability, peace, and economic growth that ended with the decades of war, inflation, and financial crisis after 1770.

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[5] Roadside inns where merchants and caravans could rest and recover from the day's journey in safety, as well as convenient rest stops for the men and animals transporting gunpowder and other military goods.

Maintaining the highways between Istanbul and frontier provinces, such as Buda in the west and Baghdad in the east, represented a large expenditure for the state. To cut back on costs associated with road building the state relied extensively upon drafted labor for building and maintaining roads; the men were either paid below market wages or not paid at all (Quataert 1994:15). It is difficult to calculate the exact costs because of the near-impossibility of estimating local labor input, much of which was unregistered. We can therefore offer only a rough idea of the expenditures the state made to build and maintain its road network. Between 1881 and 1897, the only years for which detailed figures are available, 823 kilometers of new roads were built each year and 450 kilometers repaired. This increased the total road network from 6,500 kilometers to 14,395 kilometers in 1895 and to 23,675 in 1904. Though this was a considerable increase, it was still not very much for an empire that covered 3,272,350 square kilometers and had a population of over 20 million (Shaw 1977:228).

In the second half of the 16th century, the chief imperial architect, Sinan, recruited a large labor force tasked with military and civil building works, including the construction of roads, such as those to Serbia (Cerasi 1988:87). Most of the major roads used by the Ottoman army permitted the passage of heavy gun carriages (Faroqhi 1982:17), and Sinan kept this in mind as he ordered several hundred miles of roads leading to and from Serbia to be built and improved upon. Serbia lay at an important crossroads in the Ottoman Balkans, linking Buda and Vienna with Sofia, Edirne, and Istanbul, and any army traveling from Anatolia to the border with Austria had to pass

through it. These roads proved to be beneficial in the following decades as the Ottomans faced increasing pressure on their forces garrisoned in Hungary and along the Danube.

After the conquest of Hungary, the Ottomans formed a flotilla on the Danube at the maritime arsenal near Rusçuk (Ruse). It composed of galleys, frigates, and the Hungarian *saykas.* The *saykas* was an open kind of boat, on top of which could be laid special water-resistant skins making it particularly suitable for transporting gunpowder along the Danube (Bostan 2007:11). The goal of this transportation flotilla was to resupply any Ottoman forward fortresses or armies in northern Hungary with supplies and gunpowder from the regional storage depots along the Danube, as quickly as possible.

In the west

The campaign season in the Balkans lasted from May to early November. April was reserved for the important task of grazing the horses on the vitamin-rich spring grasses, but the nutritional needs of horses were only part of the limitations on the army's movements and range of operations (Murphey 1999:21). On May 10, 1529, sultan Suleiman 'the Magnificent' left Istanbul at the head of his army bound for Vienna. He had ordered the shipyard of Izvornik to construct 150 small transport ships for use in the Danube flotilla, which was charged with supplying the army with munitions and gunpowder throughout the campaign (Imber 2002:22). The official war diaries of Suleiman tell of storms, cold weather, and constant heavy rains (Parry 1976:83), which made supply and transport problematic. The army was obliged to cross several rivers,

which it had to span using costly and time-consuming pontoon bridges because no permanent bridges had been built in preparation for the campaign. Roads likewise had to be laboriously constructed over difficult ground for the heavy cannon and huge baggage trains. This combined with the relentless rains and swollen bridges put the Ottomans one vital month behind schedule. The army did not reach Belgrade until mid-July or Vienna until September 27, a full four and a half months after it set out.

The Archduke of Austria, Ferdinand I of Habsburg, made use of the Ottoman delay to garrison Vienna with a strong force of experienced soldiers and large quantities of foodstuffs and munitions. Because of the various logistical difficulties, the Ottomans had no time to bring their large siege guns all the way from Istanbul, and their portable light guns were not enough to overcome the defenses of Vienna. Furthermore, the Ottoman army could not remain in the field long enough to starve the city into surrender or to wait for the heavy Ottoman siege guns to arrive. Instead, because the campaigning season was already drawing toward a close, Suleiman ordered the retreat back to Ottoman territory on October 14. This experience, combined with the next year's similarly indecisive campaign, made the sultan realize that distance from his supply bases was a foe at least as formidable as the power of his European rivals (Parry 1976:84).

The sultan's next campaign into the Balkans, in 1543, was organized with elaborate care and attention to the minute details of logistics and transportation. Between 1529 and 1543, Suleiman I had learned the strategic value of roads and bridges and built several to facilitate the movement of his army and the transportation of supplies. The sultan gathered his army at Belgrade, as well as large stores of gunpowder and munitions,

well in advance of his planned campaign. In the summer he launched a campaign to conquer his main objective, the fortress of Gran, which he captured on September 4 (Parry 1976:93). His frontier commanders went on to achieve further successes, capturing the fortresses of Nograd, Hatvan and Visegrád, while his Bosnian troops captured Velika in Slavonia and won battles in the region of Varaždin and Lonska. Realizing that he could not hope to counter the Ottomans speed of advance or efficiency of resupply, Ferdinand sought and obtained a truce in 1545 (Parry 1976:93). Superior transport systems gave the Ottomans great advantage at the height of their power in the mid 16th century.

Following the great Hungarian war (1593-1606), the Ottomans faced another serious threat: a new revolt in their Balkan provinces. In 1594 Moldavia, Transylvania, and Wallachia, which were previous subject to the sultan, rose in rebellion and allied themselves with the Ottomans' bitter enemy, Austria. Because the was the major water transportation route for guns and munitions to the Hungarian front, the defection of these three principalities at once severed the vital link between Istanbul and the Ottoman forces in Belgrade, Buda, and Gran (Parry 1976:118). It broke the state's lines of supply and communications to its forces on the Hungarian frontier, threatening catastrophe in its European domains. Due to the Ottomans' inability to reinforce their frontier garrisons with troops and munitions, their Hungarian defenses started to collapse. In 1595 Gran, the northernmost bulwark of the Ottoman defenses, fell to Austria. At the same time the Ottoman army directed against Wallachia suffered a disastrous rout at Giurgiu on October 26 on the lower Danube (Parry 1976:119).

The Ottoman situation in the Balkans was dire and worsening fast. The next year the sultan Mehmet III himself led his armies into the field. He aimed to cut the Austrian line of supply and communications with Transylvania at the north-eastern Hungarian fortress of Erlau. On October 12 1596, the Ottoman forces captured Erlau before Austrian reinforcements could reach it over the poor roads between Buda and Erlau (Parry 1976:119). Mehmet III's decisive maneuver successfully prevented the troops in Transylvania from receiving much needed gun and gunpowder supplies from their allies in Austria.

During the 1597 campaign against the Hapsburgs to the north and west of Buda, the Ottomans employed 320 transport ships and *saykas* for grain, artillery, cannons, ammunition, and gunpowder. However, the lower Danube was only partially navigable due to heavier than normal rainfall, and supply ships were unable to enter it from its mouth on the Black Sea. The Danube was only navigable from Ruscuk (Belgrade) to Buda (Estergon); thus the Ottomans shipped cannons, ammunition and gunpowder from Istanbul via the Black Sea to Varna, where they loaded unto them into carts and transported from Varna to Ruscuk. There they loaded the supplies onto ships (Ágoston 2005:52). The Ottomans sought solutions to solve their sometimes complex transportation problems and successfully combined both land and water transportation to meet the needs of their advancing armies.

In the east

In 1554, Suleiman led his forces east to recover ground lost to the Safavids in Armenia, in an attempt to weaken the Safavid position along their mutual frontier. Because no seas nor major rivers existed in this theater, the campaign relied extensively on ground transportation for gunpowder and supplies. Speed was of the essence, as each campaign had to be carried out in the short window of time before the long and harsh eastern Anatolian winter set in, making retreat difficult or impossible. During the campaign, however, problems of transport were not easily overcome. The mountainous terrain proved extremely difficult for road construction, and the Safavid light horsemen were able to harass the slow moving Ottoman supply lines with impunity, retreating quickly into the mountain fastness. The loss of camels and other beasts of burden put a severe strain on the Ottoman supply system, and the loss of gunpowder in particular was a factor in the Ottomans' decision to withdraw before completing their objectives (Parry 1976:94).

During the 1569 Ottoman campaign to conquer Astrakhan, at the conflux of the Volga River and the Caspian Sea, the Ottomans planned to construct a canal between the Don and Volga rivers. The canal would have given them a direct water route from the Black Sea to the Caspian. The Ottomans intended to use this route to transport men, guns, and munitions into northern Persia and the Caucasus, avoiding the long and treacherous overland supply route (Parry 1976:112). But the Astrakhan campaign was a failure. The Ottomans were forced to stop digging the canal, limiting the speed and quantity of gunpowder they could send into this troubled border region occupied by Russia and the

Safavids. In addition to this failed attempt to improve the efficiency of Ottoman transportation networks, the long years of conflict during the late 1500s with both Persia and Austria strained the state's capacity to gather enough saltpeter to manufacture sufficient quantities of gunpowder for the demands of two different fronts. As a result the Ottoman Empire was briefly forced to import large quantities of saltpeter and gunpowder from England, whose merchant companies were keen to tap into a lucrative market in the Eastern Mediterranean (Parry 1976:124).

Suleiman's campaigns highlighted the difficulties faced by the Ottoman Empire in the east. Long distances, high elevations, cold weather, and rough terrain, all made road and bridge building more time consuming and costly, and sometimes impossible with the technology available at the time (Parry 1976:112). The Safavid forces of the shah made excellent use of scorched earth tactics while avoiding battles and continually harassing Ottoman supply lines. Their raids threatened Ottoman supplies of munitions and gunpowder. The logistical nightmare of transportation hampered the Ottomans from a swift and permanent conquest of the area east of Lake Van and in the Caucasus in the 16th century.

Bridges

The state and the military establishment recognized the need for a dependable network of roads and bridges to connect their far-flung empire and to enable rapid communication and transportation of critical goods, such as gunpowder. The 1635 campaign against Erivan demonstrated the critical wartime need for reliable bridges. The

army's progress was halted by the collapse of the bridge over the Kızılırmak River on the western approaches to Sivas, where it was forced to stay for 16 days while it rebuilt the bridge (Murphey 1999:67). When the army finally arrived at Erivan it was critically behind schedule, and made no gains before it had to return to its winter quarters in Ottoman territory.

The Ottomans used two methods for constructing bridges during wartime. The first was a temporary bridge that was vulnerable to enemy attack and constructed only when the army did not have enough material on hand to build a sturdier pontoon bridge. The army carried pontoon bridges in its baggage train, and built them with the intention of dismantling them for re-use later. The Ottoman historian Nihadi described how the Ottomans used bridges in their 1696 campaign, culminating in their victory at the battle of Cenei near Temeşvar. He recounts that two bridges, transported in 33 ox carts in the baggage train, and consisting of fifteen pontoons each, were built over the Timiş River by the army's engineers in just three hours (Murphey 1999:24). The crossing of the troops over these bridges, however, was a slow and careful process, and attempts to hasten the march over the flimsily-constructed structures put them under threat of collapse.

At the start of the Grand Vizier Köprülü-zade Fazil Ahmad Pasha's campaign in the spring of 1663, his army marched from Edirne to Uyvar. The Grand Vizier departed on time from Edirne on March 14, 1663, but spent several weeks waiting to pasture the army's horses and to complete provisioning at Sofia. The army reached the Drava River at Osek 74 days after its departure from Edirne, and had to wait there an additional eight days while pontoon bridges were made ready for the assembled troops to make the

crossing (Murphey 1999:66). The total travel time from Edirne to the Drava River crossing took the Ottomans 85 days; 39 days were spent in movement and 46 in rest. The army marched an average of 4.64 hours on its mobile days, making the march 181 hours in total. Murphey hypothesizes that the majority of days spent resting on this campaign may be attributed to frequent river crossings on the army's march (Murphey 1999:67).

In August 1664, the Ottoman army was operating with a free hand in southern Hungary in the vicinity of Szentgotthard (Saint Gotthard), whose geography was defined by the Raba River. Due to insufficient rains the year before, the river was at low ebb, and the vanguard of the Ottoman forces was able to ford the river near Saint Gotthard without having to suffer the delay of bridge construction, while a large part of the army and all of the artillery remained on the near side. Overnight a sudden storm caused heavy rains to fall in the mountains and the river burst its banks, cutting off the vanguard from the bulk of the army (Rycaut 1970:208). Ottoman engineers quickly and efficiently built a pontoon bridge over the river to reopen communication and transportation with their forces on the far side. They were able to move a portion of their heavy cannons forward over the bridge and successfully bombarded Saint Gotthard until it surrendered. Raimondo Montecuccoli, the Habsburg general in charge of the defense of Saint Gotthard commented on the Ottomans' cannons:

> This enormous artillery produces great damage when it hits, but it is awkward to move and it requires too much time to reload and site. Furthermore, it consumes a great amount of [gun]powder, besides cracking and breaking the wheels and the carriages and even the ramparts on which it is placed . . . our artillery is more handy and more efficient and here resides our advantage over the cannon of the Turks (Kinross 1979:187).

The Ottomans' methodologically planned springtime campaigns were often disrupted by their enemies' unorthodox guerilla tactics. During the winter of 1664 in southern Hungary, the swift and decisive guerilla actions led by the Ban of Croatia, Nicholas Zriny, successfully cut off all communications between the capital and its frontier outposts and threatened to throw the entire region into chaos. With a small force of only 4,000 commandos Zriny estimated that he could best disrupt the Ottomans' upcoming spring campaign by striking at their transportation network. Able to move more or less at will during the snowy months when the Ottoman troops were in their winter quarters, Zriny struck against the bridge at Osek, which guarded the supply and communications lifeline between the front in Hungary and the Ottoman munition depots along the Danube (Murphey 1999:123). The attack was so rapid that the Ottomans were unable to catch the guerrilla raiders before they withdrew beyond the frontier. When the Grand Vizier Fazil Ahmad Pasha reviewed the damage done to the bridge he ordered work crews to carry out immediate repairs, which were necessary before it could be restored to operation (Murphey 1999:123).

As a result of Zriny's bold winter offensive, work crews were kept busy throughout the winter and spring to restore the bridge to a useable condition. Preoccupied with this project, they were unable to construct roads and bridges for the Ottoman spring counteroffensive. In consequence, when the grand vizier's finally crossed the bridge on May 20, they were already late in starting the campaigning season. They took a calculated risk and left behind the army's heavy siege guns to facilitate a quicker pace. The fortress of Kanizsa, which had been under siege by Zriny's troops for four weeks,

was liable to fall any day. The gamble paid off, and the advance part of the Ottoman army under the grand vizier was able to reach Kanizsa in time to save it from the enemy. Meantime, four bridges had to be constructed to transport the heavy siege guns over rivers and swampy ground between Sophia and Kanizsa (Murphey 1999:126). Once complete, these bridges connected the roads in the province, allowing the grand vizier to transport gunpowder and munitions quickly as his army pushed to end Zriny's attacks.

With their road and bridge network in good working condition, the Ottomans took the initiative against Zriny and brought up 5 *kantars* of gunpowder and large numbers of cannon balls to feed their heavy artillery as it battered down the walls of Zrinvár, Zalakomár, and the major fortress of Poloske, which were Zriny's main bases (Murphey 1999:127). The Ottomans' main intent in capturing these fortifications was not to extend their territory, but to prevent future raids against their sensitive yet critical transportation network in southern Hungary.

The Ottomans' excellent bridge and road network enabled them to transport gunpowder quickly from its place of manufacture to where it was most needed by their armies, giving them an important tactical advantage. The system did not always function as intended, and, like their enemies, the Ottomans had to devise new strategies to fit every unexpected circumstance.

Army/gunpowder movement times and costs

Overland transportation during the 17th century was slow and costly, and transport costs for wartime supplies by water or by land always represented a serious item of

expenditure in any Ottoman campaign. For example, it required 11,000 cartloads of food for men, fodder for animals, and munitions such as gunpowder to supply an army of 90,000 men and 40,000 horses for 30 days in the field (Perjés 11). Translating this into the realm of Ottoman ground transportation, assuming an average load of 250 kg per camel, animal fodder alone (7,600,000 kg) for an army of this size would require at least 30,000 camel loads (Murphey 1999:100). These costs could be held at more reasonable levels in areas of the empire where well-maintained roads facilitated quicker movement, such as in the core provinces, which had well developed administrative structures enabling them to maintain state roads to a high standard (Murphey 1999:78).

Troops on the march could cover on average 13.5 miles per day in optimal conditions, and less in bad weather to avoid advancing too far ahead of baggage trains. The baggage trains proceeded at about 2 miles an hour and needed over six hours to reach the forward camp at the end of the day's march. Because road and weather conditions were rarely consistent or predictable, there was no accurate way to schedule the arrival of an army. Even so, it is useful to have some base measure of troop speeds under optimal conditions. Perjés calculated the Belgrade to Istanbul march as a round figure of 1000km (621 miles), which he determined would take 77 days. This estimate included 20 days in which the army did not make much forward progress as it was resting or crossing rivers. Of the other 57 days, the average rate of advance was 17.5km (11 miles) per day. The average rate of advance including rest days was only 13km per day (Perjés 1989:33-37)

One method the Ottomans used to increase their armies movement speed was to manufacture cannons of various sizes on the spot during a siege, thus bypassing the need

to transport them anywhere. The state had both the resources and organization required to cast guns in the field, which gave it a major tactical advantage over their enemies. During the siege of Baghdad in 1638 the Ottomans improved their position significantly by drawing upon local resources to supplement their hardware. They cast five siege guns of medium size (70 pounders) and three smaller guns (50 pounders) at Birecik on the Euphrates, and floated them by boat downriver to the siege, where they contributed to the fall of the city (Murphey 1999:109).

Naval transport

The Ottoman navy played an instrumental role in the transportation of gunpowder from its place of manufacture to forward storage depots. The Ottoman Empire struggled with a problem experienced by all gunpowder countries: how to store large enough quantities of gunpowder aboard its ships without it getting wet. Having a system of keeping gunpowder dry onboard ships was important because the Ottomans transported a great deal of gunpowder to their armies by way of the Mediterranean, and for it to arrive spoiled was a ruinous waste of time and money.

The Ottomans garrisoned the city of al-Hasa in the present eastern province of Saudi Arabia between 1550 and 1670 to reinforce their border with the Safavids in Iran. During their occupation the Ottomans relied extensively upon river transport for supplies, both civilian and military, because land transport in any case was liable to be raided by nomadic tribes in the area. All military supplies and equipment, as well as materials for fortifications, such as tools, wood and iron, had to be transported to al-Hasa from Iraq

down the Euphrates to Basra. In March 1572, the governor general of Basra received a request to forward 300 *kantar* of powder to al-Hasa and to send an official with the shipment to investigate the possibility of setting up a powder factory there (Mandaville 1970:509).

In the Hungarian theater, where the Ottomans were critically involved between 1540 and 1690, the rivers became the lifeline to their armies operating in the interior. The development of a system of river transport became of extreme importance. During the Great Turkish War (1683–1699), the Ottomans were engaged in countering the onslaught of Austria, Poland, Venice, and the Russians in southern Hungary against their positions. The transport of gunpowder to the Ottoman armies was kept open by their river fleet on the Danube that numbered 52 vessels and 4,070 crew (Murphy 1999:235). By keeping control of the fortress of Titel, which guarded the convergence of the Tisa and Danube, and the fortress of Osek, which protected the junction of the Drava-Danube, they were able to keep their armies supplied with munitions. The situation changed, however, once Buda and Pest were retaken by Austria in 1686, which affected river transportation and put the Ottomans on an equal footing with rival armies who relied solely on slow and dangerous overland transportation methods (Quataert 1994:534). With the loss of the upper Danube and its tributaries to Austria, the Ottomans could no longer use the fleet to resupply their armies. The extension of Ottoman power in Hungary became impossible to sustain. From the late 17th century onwards, the Ottoman Empire witnessed the steady decline of its western frontier, culminating in 1774 with the Treaty of Kücük Kainarci. This treaty forced the Ottomans to cede the port of Kherson between the Dnieper and

Southern Bug rivers to the Russia Empire, giving the Russians their first warm-water port on the Black Sea and passage through the Dardanelles and deprived the Ottomans from important sources of revenue.

Naval arsenals

By the mid-16th century, Ottomans and their European rivals transitioned from galleys, which relied on human oar power for movement and had been used in Mediterranean warfare for thousands of years, to a new type of ship that relied upon huge sails to harness the power of the wind. This new ship, the carrack, allowed gunpowder and cannons to play an increasingly significant role in naval warfare. The low sides of galleys, necessary for the motion of the rowers, made them less able to support the massive weight of cannons, which by the 15th century weighed an average of three tons (Kelly 2004:89). In contrast, the carrack offered the ideal platform for cannons. Their increased buoyancy countered the guns' enormous weight, and because they needed no rowers to man the oars, they could accommodate personnel to load, aim, and fire the guns, as well as the tons of gunpowder necessary to use them.

In preparation for an engagement at sea, the Ottoman navy built and maintained state of the art naval arsenals at Gelibolu, the Istanbul Naval Arsenal (*Tersane-i Amire*) on the shore of the Golden Horn, Izmit on the Sea of Marmara, Samsun on the Black Sea, Suez on the Red Sea, and Birecik on the Euphrates (Ágoston 2005:50). The Ottomans built their first naval dockyard in Gelibolu (Gallipoli) in the 1390s, initially with only two bays for the construction of ships (Ágoston 2005:18). They constructed the Istanbul

Naval Arsenal during the reign of Selim I, and by the 1550s it had become the main center for shipbuilding and maintenance. Between 1610 and 1664 the Istanbul Naval Arsenal constructed 180 new galleys and 59 large galleys, and repaired 413 galleys and 102 large galleys (Bostan 2007:98). At these arsenals the navy stored large quantities of munitions, including cannon balls for all calibers of cannon, round shot for muskets, and upwards of 100 tons of gunpowder. The gunpowder was stored in casks which specially trained skilled laborers carefully loaded directly from their stores in the armory to the warship holds.

The gunpowder aboard a ship represented the ultimate determiner of life or death to those on board, and was often surrounded by sailors who had been pressed into service and who lived for months on end in grueling living conditions. Therefore, once onboard, gunpowder was stored in the magazine, or a kept in a strictly secured room in the middle of the ship. This room was made safe from dangers such as water leakages, stray sparks from candles or lanterns, or enemy attack. Workers in the magazine had their only illumination from an adjoining lit room, a closet containing lanterns whose light shined in through thick panels of glass (Kelly 2004:103).

During an engagement, the gunner loaded gunpowder from the ship's magazine into cartridges, sacks made of paper or cloth, to use in the ship's cannons. The question of how much powder to use was often posed in the 14th-15th centuries. Manuals gave many different formulas: "Multiply the weight of ball by the number of diameters of the chase in the circumference of the breech", or "the product multiply by 6, the last product divide by 96, the quotient gives the pounds required to charge the piece in action" (Kelly

2004:103). Before the corning of gunpowder, the powder aboard ships was of inconsistent quality and its explosive power in most European navies varied widely. But even the Ottoman's pre-corned gunpowder was more consistent because of their manufacturing and transportation methods, as described above.

In the Indian Ocean and the Red Sea

The Ottoman government constructed a navy to guard the Red Sea and the holy cities of Mecca and Medina from infidel attack and to protect Muslim shipping from the Portuguese, who were eager to control trade in the Indian Ocean. In 1509 the Mamluk sultan sent a large fleet of galleys into the Indian Ocean under command of admiral Hussein Pasha in an attempt to protect Muslim trading interests there. In a battle off the Indian port of Diu, the Portuguese won a decisive victory and sank many of the Egyptian ships.

To follow up on their success at Diu, in 1517 the Portuguese decided to attack the port of Jiddah for several reasons. By capturing Jiddah the Portuguese would cut off Ottoman trade in the Red Sea, as Jiddah was the terminus for all shipping of north-bound coastal trade. Its capture would also place the Portuguese within striking distance of Mecca, Islam's holiest city. An attack on Jiddah would bring the Portuguese navy into direct contact with the might of Ottoman land based artillery. Both the Portuguese and the Ottoman fleets contained a large number of galleys, which were deemed the most useful vessels for navigating in the Red Sea (Guilmartin 2003:26). However, the

Ottomans had the advantage of being able to position three or four basilisks,[6] capable of firing cut stone balls of around 1,000, pounds in defense of Jiddah's harbor (Guilmartin 2003:26). For the first time in the east the Portuguese were faced with the might of Ottoman land based artillery, and this presented them with a tactical problem. The channel leading to Jiddah's harbor was too narrow for the Portuguese to force their way in, and after several unsuccessful attempts they withdrew. It is unlikely that the Portuguese could have anticipated this combination of land based artillery and Ottoman galleys that put up such a formidable defense (Guilmartin 2003:27).

The Ottomans continued to maintain their presence in the Red Sea in order to secure their trading rights and to support other Islamic states. During the reign of Suleiman the Magnificent (1520 - 1566), fleets, soldiers and munitions, were sent to support Muslim rulers in Gujarat, Ethiopia, and Aceh (on the northern tip of the island of Sumatra), and to defend the Ottoman spice and slave trades. In Aceh, the Ottomans built a fortress and supplied it with cannons and gunpowder to defend it against the Portuguese (Imber 2002:61).

In 1538, the Ottoman governor of Egypt Süleyman Pasha devised a strategy to drive the Portuguese from Diu on the west coast of India by besieging their fortress built in 1535. For this operation the Ottomans assembled a fleet of 80 ships, including 2 galleons and 17 galleys, the largest fleet they ever sent into the Indian Ocean (Black 2002:61). The Ottomans bombarded Diu with over 130 cannons of various calibers, though withdrew when news came that a strong Portuguese relief force had been sent

[6] A very heavy bronze cannon.

from Goa (Quataert 1997:325). The attack, supported by a rebuilt Ottoman fleet, failed due to the timely arrival of reinforcements from Goa, whereupon Süleyman Pasha gave up any future attempts to strike at Portuguese bases in the Indian Ocean.

Transportation summary

The Ottoman Empire developed a finely tuned system of army provisioning, as good as any in the world at the time. Nevertheless, much of any typical campaign season had to be left to chance, with variations in weather, the morale of soldiers, and even the reliability of the arms and equipment sometimes determining the outcome. Warfare, therefore, was less a matter of prior planning as "somehow managing to beat the odds" (Murphey 1999:87). Whatever potential advantages there were for the Ottomans or their rivals in manufacturing and using the most advanced weapons of the day could be, and often was, mitigated by the supply and quality of their gunpowder. Several factors, including unpredictable weather, high river levels, and manufacturing and transportation accidents, could lead to the delay in the delivery of gunpowder to armies at the front.

In the European theater the Ottomans were favored by geography, being able to transport supplies and gunpowder on the Danube to within a few days' march of any prospective front. During the 15th to the mid-16th centuries the Ottomans experienced great success in sieges, due to their better cannons and more reliable gunpowder than any of their enemies, but they did not fare as well in field battles. The Ottoman Empire's slowness at adapting to lighter field artillery like their rivals, Austria and Russia, caused them to lose 80% of field engagements between 1550 and 1800 (Ágoston 2005:201). For

example, on the Danubian frontier fifteen major field battles took place in as many years between 1683 and 1697. Out of these engagements the Ottomans won just two. One ended in a draw, and Europeans won all the others (Ágoston 2005: 201). By the end of the 17th century, the Ottoman Empire had been pushed back in the Balkans and lost Azov to Russia, Morea to Venice, and all of Hungary to the Habsburgs.

During the period of 1500-1700 both the Ottoman Empire and their western rivals improved their methods of manufacturing and transporting gunpowder. The Ottomans established gunpowder production facilities in Istanbul and several major provincial centers and produced gunpowder on a massive scale. They maintained an enviable advantage over their enemies up until the late 18th century, in terms their gunpowder. Ultimately, the gunpowder technology used by both sides was still in early stages of development and prone to failure at unexpected and critical times. The reliability of even the most sophisticated weaponry was limited to successful pairing with the best quality gunpowder, and since these two necessities were rarely met between the 14th and 17th centuries, the advantage gained from superior military technology remained largely theoretical (Murphey 1999:15).

CHAPTER 5

A SERIOUS THREAT: THE DECLINE OF OTTOMAN GUNPOWDER MANUFACTURING AND TRANSPORTATION

A serious threat to the stability of the Ottoman Empire began in the late 17th and early 18th centuries with the decline of its national gunpowder production levels. By the late 17th century the Ottoman saltpeter mining industry and transportation network had fallen on hard times (Ágoston 2005: 204). In 1693-94, 65% of the saltpeter delivered to the gunpowder mills in Istanbul had to be purchased; only 208 metric tons of saltpeter or 35% of the total was produced in the *ocakliks* (Ágoston 2005:126). The amount of saltpeter necessary for an entire year's campaign in the late 17th century could be bought for the amount paid to the Janissaries in just one month (Ágoston 2005:127). Transportation throughout the empire also experienced periods of near collapse due to revolts, such as the one led by Patrona Halil in the 1730s, which put additional strain on the gunpowder industry.

Gunpowder works all over the empire were shut down by the state or maintained so poorly that total production levels fell to just 15-30% of the output levels of the 16th and 17th centuries. Further compounding the problem, the state lost its tight control over gunpowder production during the period of decentralization in the 18th century. In 1765, large quantities of gunpowder were being imported into the Ottoman Empire from

Holland and Venice (Grant 1999:196). Paul Rycaut, an English observer, noted that by the latter half of the seventeenth century "their [the Ottomans] Gunpowder is made only in small quantities about Istanbul, but comes from divers places of Europe and that from Damascus is most esteemed" (Rycaut 1970:213). Those gunpowder production centers which were still kept in operation did not produce sufficient gunpowder, as evidenced by the large shipments of powder the state was receiving from Sweden and Spain by the second half of the 18th century (Grant 1999:85). Furthermore, some Ottoman gunpowder mills continued to produce powder using the outdated 16th century formula, while Europe had been using a more stable, higher quality powder since the early 1700s (Grant 1999:195).

As a consequence of the Ottoman Empire's humiliating defeat in the Russo-Turkish War, they were forced to accept the Treaty of Berlin, which was signed into effect in July of 1878. As part of the treaty, the Ottomans were required to grant independence to Romania, Serbia and Montenegro, and autonomy to Bulgaria. This led to a significant loss of tax revenue from these highly industrialized provinces. The economic situation in the Ottoman Empire after the Treaty of Berlin suffered further because the Ottomans had to pay huge war indemnities to Britain, Austria-Hungary, and Russia, which reduced government's income to a fraction of what it used to be and put an effective stop to the sultan's plan for rebuilding the empire's military capacity.

The economic weakness was revealed in the Ottoman's armaments policy. The government increasingly lacked the money to modernize its industrial sector to keep up with the industrial capabilities of Britain, France, or Germany. As the Ottomans'

domestic gunpowder and armaments industry fell behind foreign producers in terms of quality and quantity, the state shifted from producing the majority of its own gunpowder and arms to importing these crucial war materials from Western European countries. It was seen as more economical for the government simply to supply itself from foreign arms manufacturers rather than investing time and money in its domestic arms industry (Grant 1999:195). The Ottomans feared relying too much on any one supplier of weapons because they could exert undue influence by withholding arms shipments. Therefore, the state tried to minimize risks by purchasing arms from several foreign suppliers, but it either did not see or did not care about the danger of halting domestic gunpowder production and being at the mercy of foreign suppliers.

Another factor in the Ottoman decentralization was that, by the 18th century, it became difficult to maintain a successful manufacturing sector in an empire whose economy as a whole was tied closely with the Mediterranean region. Earlier the dar-al-Islam had been a center of trade, culture and innovation, but by the 1800s it was evident that trade and communication no longer passed overland from Asia through the Middle East, but instead was dominated by European shipping lanes in the Atlantic and Pacific Oceans. Economic stimulation was only one advantage the Middle East lost with the rise of the importance of sea power on international commerce. Contact with the outside world, which brought with it new ideas and inventions, also gravitated towards Europe and away from the Middle East. As a result, the economic and cultural situation in the Islamic world stagnated.

Conclusion

The overall strength of early gunpowder empires depended on the central administration's control of local resources and the effective utilization of these resources. In the 16th century, the Ottomans had a highly trained and loyal bureaucracy to match their army, which brought them success on the battlefield and in international diplomacy. Ágoston is correct in his answer to the question: "What went wrong?" He argues that it was not better guns, ammunition, or gunpowder that gave Europeans the advantage, but better drill, command, and administration in the 18th century (Ágoston 2005: 201). His picture is incomplete, however, because it fails to look at the significant role the decline of the gunpowder industry played in Ottoman failures against their European rivals. Ottoman military successes in the 16th through the early 18th centuries were enabled by and dependent upon the availability of ample natural and human resources, as well as the efficient supply networks through which the state was able to deploy its weaponry, munitions, and gunpowder successfully.

The 18th century saw a growing disparity between the war industries of the Ottoman Empire and that of their European rivals. The gap was caused by the Ottoman's neighbors "adopting incremental innovations, such as galleons, frigates, new techniques of cannon-boring, light field guns, new-formula gunpowder, and flintlock firearms, as well as more advanced military drill and tactics" (Grant 1999:183). The Ottomans' failure lay not only in their reluctance to adopt more advanced European military techniques, but also because of the decline in the quality of their gunpowder due to the state's decentralization in the 19th century. Once the effects of these new technologies

became apparent to the Ottomans, as after the Russian conquest of the Crimea in 1783, they modernized their own weapons manufacturing industry. By the beginning of the 19th century, Ottoman war technology was again competitive with that of its rivals, although the state's control over the manufacture of gunpowder never recovered to its 16th century levels.

The rise of the Ottoman Empire ushered in a new era-defining paradigm of the "gunpowder nation." It created a model for its army and supply network that many nations would subsequently adopt. Before the fall of Constantinople, few nations realized the immense impact gunpowder would have on the course of world history. But an astute observer in 1453 might have drawn the conclusion that those nations best prepared to innovate and fully adopt gunpowder into their armies would someday come to dominate the rest of the world.

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